

Title: Data captured using low-cost active electromyography

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Abstract: Surface electromyography (sEMG) data was captured for three able-body subjects, from their right biceps brachii using the POLE sensor outlined in "Low-cost active electromyography" [1]. Data was captured for 45 seconds per subject, resulting in 12–21 contractions per subject. The raw data files, along with a sinusoidal waveform have been provided. This allows users of the POLE sensor to verify their low-cost sEMG device has been populated and configured correctly. This data also allows researchers/developers to compare their results against this low-cost, low noise sEMG device. The frequency content of the raw sEMG data is also of interest; this is calculated by applying a fast Fourier transform (FFT). The process applied to perform these algorithms is supplied in a MATLAB script.

Keywords: sEMG, EMG, Rehabilitation, Right Leg Driver, Bar Electrodes, Bio-sensing, Bio-instrumentation

Specifications table:

Subject	Engineering
Specific subject area	Biomedical Engineering
Type of data	Figures, .csv
How data were acquired	A custom sEMG (POLE [1]) sensor was used to record the bio-signals
Data format	Raw and processed
Parameters for data collection	Raw sEMG from three able-body subjects were recorded from the biceps brachii
Description of data collection	While the subjects were seated with their right elbow at approximately 45 degrees, multiple contractions from the biceps brachii were recorded using Ag/AgCl electrodes
Data source location	Centre for Bioengineering, University of Canterbury, Christchurch, New Zealand
Data accessibility	https://data.mendeley.com/datasets/wbn3h63tnp/1
Related research article	Author: B. Fortune, C. Pretty, L. Chatfield, L. McKenzie, M. Hayes Title: Low-cost active electromyography Journal: HardwareX DOI: 10.1016/j.ohx.2019.e00085

Value of the data

- These data allow the users of the POLE sensor [1] to verify they have correctly populated the PCB and configured the device.
- These data will help researchers who require low-cost high quality sEMG signals.
- sEMG researchers/developers can compare their device’s performance against this low noise device.

Data description

The POLE sensor contains an Analog Device’s AD7768-1 24-bit sigma-delta ADC. The POLE sensor operates from ± 2.5 V, resulting in a 298 nV quantisation. The POLE sensor is configured with a 1 kHz sampling rate. A passband of 20–430 Hz is achieved using a single order AC-coupler and a 64th order finite impulse response (FIR) low-pass filter. All data is input referred (removal of the gain applied by the POLE sensor) and saved as an array of 32-bit values.

Sinusoidal data

To verify the functionality of the POLE sensor, a 10 mV pk-pk, 30 Hz sinusoidal waveform was applied to the device’s built-in Ag electrodes. The provided file, “sine_30Hz.csv”, contains the

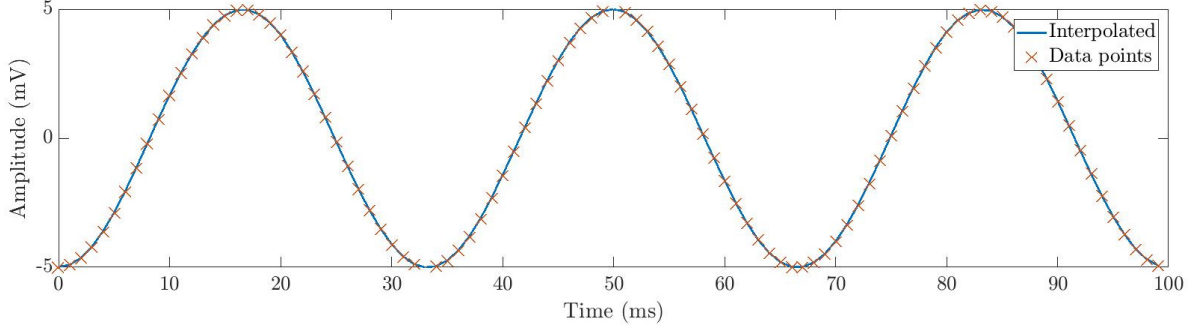


Figure 1: 10 mV pk-pk, 30 Hz sinusoidal waveform used to verify the functionality of the POLE sensor.

input referred data associated with the sinusoidal waveform, Figure 1. The file contains three cycles (100 ms, 100 data points) worth of data, where column one contains the time data in microseconds and the second column contains the amplitude data in nanovolts.

Raw sEMG

The files “EMG_raw_subject1.csv”, “EMG_raw_subject2.csv” and “EMG_raw_subject3.csv” contain the input referred sEMG submaximal contraction data, from three able-body male subjects, aged 40, 26 and 24 years old respectively, Figure 2. The sEMG data was recorded for 45 seconds, where Subject 1 performed 12 contractions, Subject 2 performed 16 contractions and Subject 3 performed 21 contractions. These files follow the format that column one contains the time data in microseconds and column two contains the amplitude data in nanovolts.

Frequency content data

Using the raw input referred sEMG data, a single sided fast Fourier transform (FFT) was produced for each subject, Figure 3.

Experimental Design, Materials, and Methods

The POLE sensor’s ADC digitises the analog voltage based on multiple built-in constants and three user defined parameters [2],

$$\text{Data} = \left[\frac{3 \times V_{\text{IN}}}{V_{\text{REF}}} \times 2^{21} - \text{Offset} \right] \times \frac{\text{Gain}}{4} \times \frac{4,194,300}{2^{42}}, \quad (1)$$

where V_{REF} is the fullscale voltage, and Offset and Gain are 24-bit calibration variables. Equation (1) was rearranged to convert the digitised data back into voltage representation data,

$$V_{\text{IN}} = \left[\frac{\text{Data} \times 4 \times 2^{42}}{\text{Gain} \times 4,194,300} + \text{Offset} \right] \frac{V_{\text{REF}}}{2^{21} \times 3}. \quad (2)$$

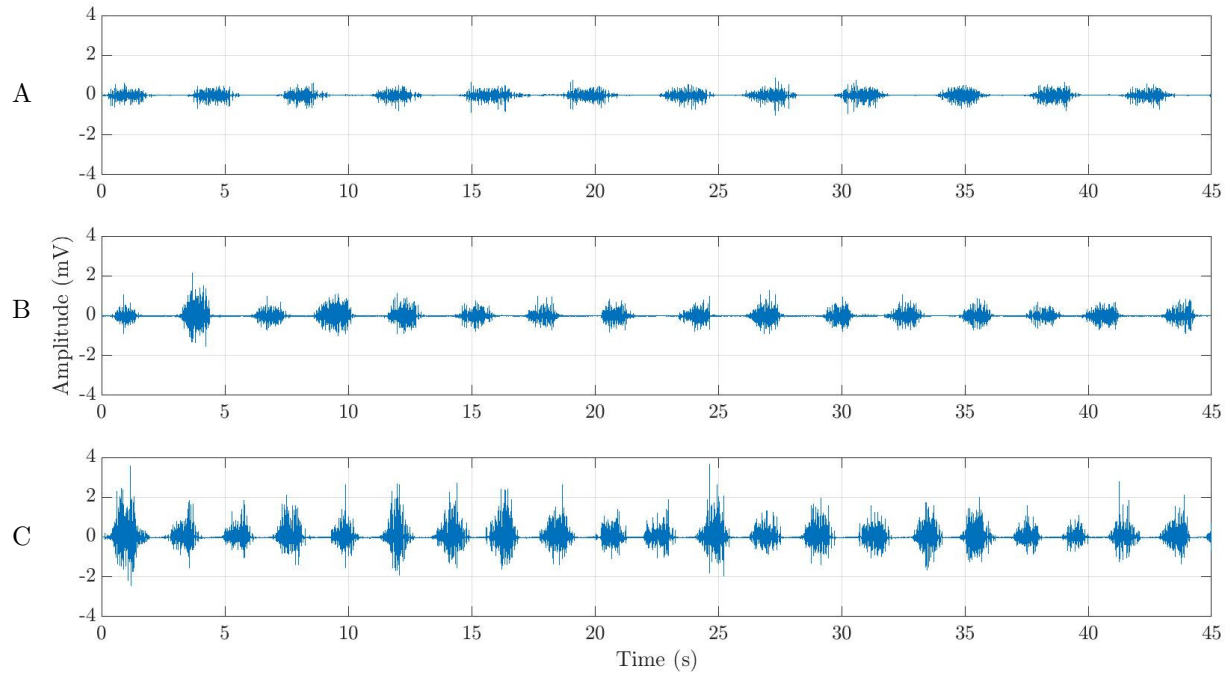


Figure 2: Raw sEMG captured from the biceps brachii contraction of three able-body subjects: A, B and C are Subject 1, Subject 2 and Subject 3 respectively.

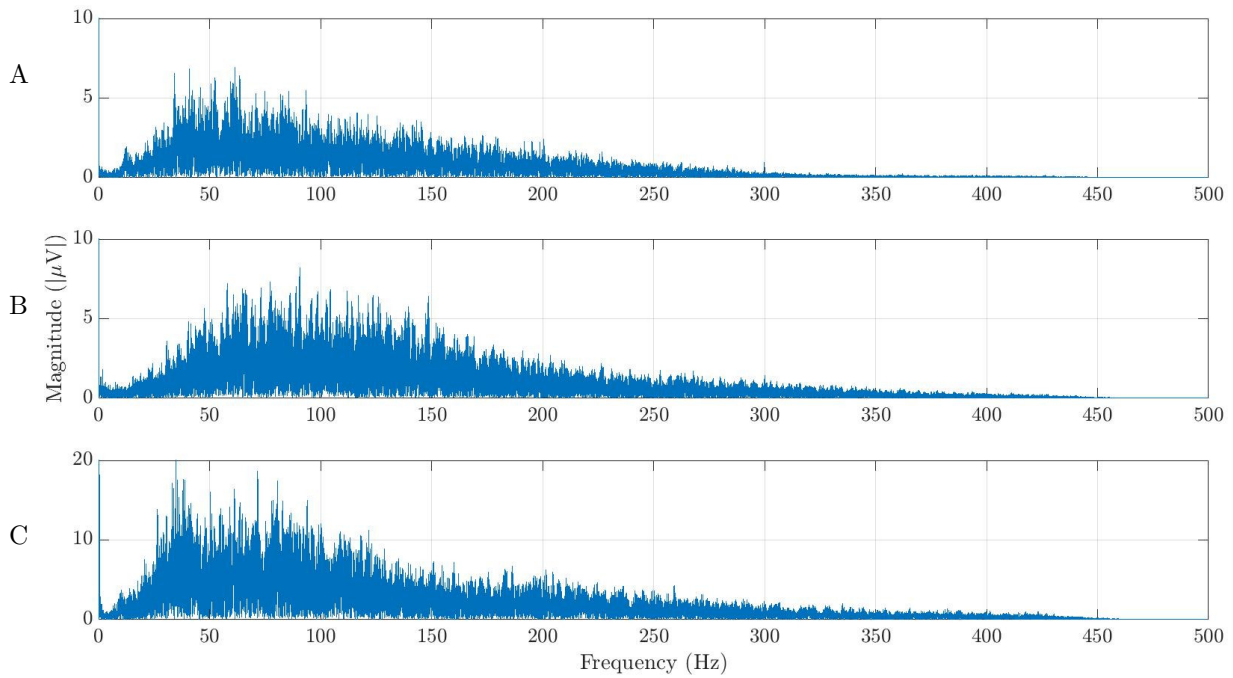


Figure 3: Fast Fourier transform (FFT) of the raw sEMG signal captured from the biceps brachii contraction of three able-body subjects: A, B and C are Subject 1, Subject 2 and Subject 3 respectively.

With the digital offset set to zero and the digital gain set to 1 (by setting Gain variable to 0xAAAAB4, 11,184,820 decimal), the digitised to voltage conversion is simply,

$$V_{\text{IN}} = \frac{\text{Data} \times V_{\text{REF}}}{2^{24}} = \frac{\text{Data} \times 5}{2^{24}}. \quad (3)$$

To achieve an input referred signal, a known amplitude sinusoidal waveform was applied to the POLE sensor and used to determine the exact applied gain. The 10 mV, 30 Hz sinusoidal waveform was produced using a Rigol DG1022U function waveform generator. The POLE sensor was interfaced with a Teensy 3.6 microcontroller, using the code provided with the sensor [1]. The only addition to the code was simultaneously printing the microcontroller’s run time in microseconds, which was used for the time stamp associated with the recording. The Arduino (1.8.10) IDE was used to capture the data and transfer it to a computer over the serial interface.

Raw sEMG

The process of recording and publishing the de-identified data was approved by the Human Ethics Committee, University of Canterbury (HEC 2019/68) and informed consent was obtained from each participant prior the experiment. The raw sEMG data was captured during sub-maximal isometric contractions of the biceps brachii, where the POLE sensor was located above the centre of the muscle belly, Figure 4. Skin preparation was achieved by performing approximately 20 light uniform sweeps over the biceps brachii using 600 grit sand paper, followed by sterilisation with 75% ethyl alcohol wipes. A minimum period of two minutes was ensured before attaching the POLE sensor above the subject’s muscle belly. 3M foam gel 2228 snap connector electrodes, with a 15 mm diameter Ag/AgCl disc, and a 40x33 mm adhesive pad were used as the reference electrode. The reference electrode was placed on the subject’s right elbow. The subjects were seated and had their right arm placed on a desk, resulting in an elbow angle of approximately 45 degrees. The subjects were instructed to perform a contraction lasting between 1–2 seconds, then rest for 1–2 seconds. This process was repeated for 45 seconds.

Frequency content data

The FFT was performed using MATLAB (R2017a, MathWorks), where a symmetric hamming window and zero padding with a factor of 8 was applied. The MATLAB script is supplied: “EMG_plot_data.m”. As the sampling rate of sEMG was 1 kHz, the FFT range is DC–500 Hz. The FFT algorithm was applied to the entire raw sEMG data per subject.

Acknowledgements

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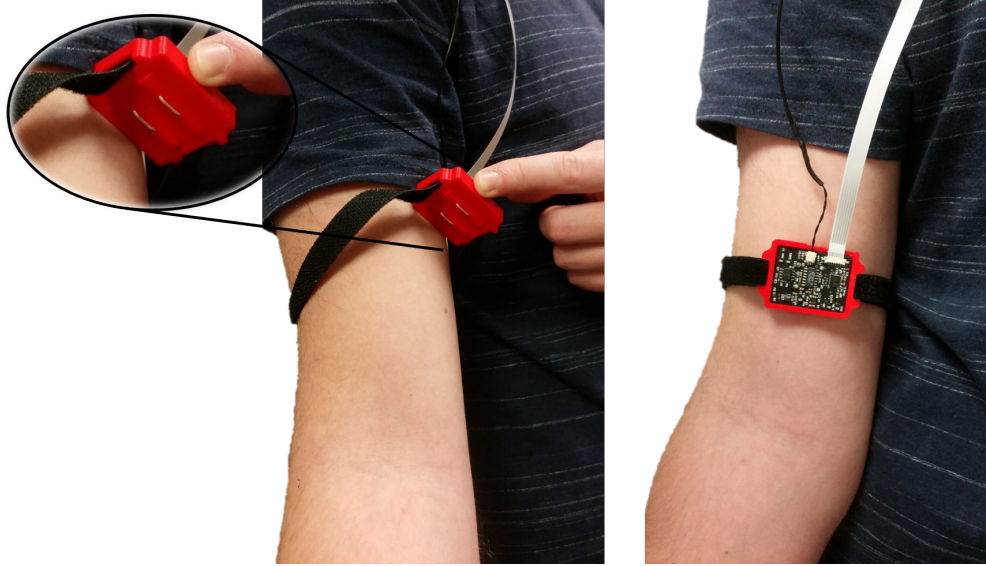


Figure 4: Electrode position for recording from the biceps brachii. The white flat flexible cable connects to the microcontroller. The black cable is the right leg driver cable, which was attached to the elbow.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

References

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- [2] Analog Devices, “DC to 204 kHz, Dynamic Signal Analysis, Precision 24-Bit ADC with Power Scaling,” AD7768-1 Data Sheet, Rev. A, 2018.